Hardware Devices Group

Group Overview

Barry Brumitt
Gary Starkweather
Mike Sinclair
Turner Whitted

H/W Devices Research

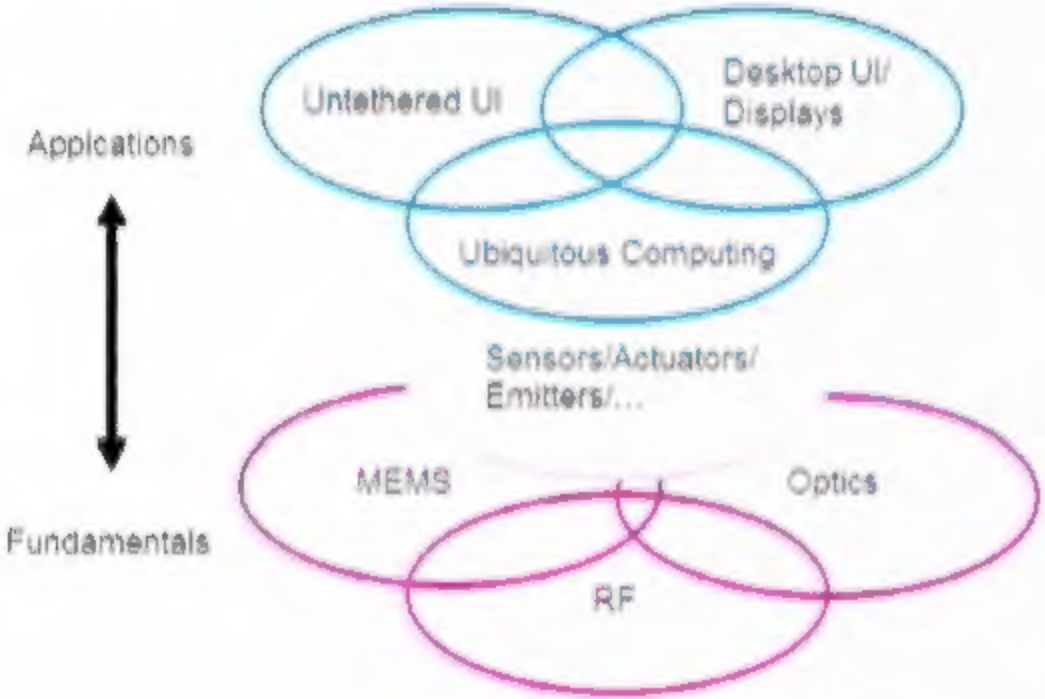
- Mike Sinclair, Senior Researcher
  - MEMS, Sensors, Multimedia, UI
- Gary Starkweather, Architect
  - Novel displays, Display UI
- Barry Brumitt, Researcher
  - Ubiquitous/invisible/location-based computing
- Turner Whitted, Senior Researcher
  - Graphics processors, PANs

Why is a software company researching devices?

Why Hardware?

- When was the last time you wrote software for non-existent hardware?
  - Hardware always leads software
- Hardware with greatest impact on MS software products
  - Displays (large, larger, very large, ...)
  - Memory (NVRAM, fast DRAM)
  - Interconnect (WAN, LAN, PAN, chip-to-chip)
  - Sensors (user state, machine state)
- Never bet against the hardware!

Technology spectrum



Projects

- Displays
  - Use (measurement, processing, ClearType)
  - Technology (IMODS)
- MEMS
  - Novel actuator projects
- UI
  - Sensor-based experiments
- Invisible/Ubiquitous Computing
  - More sensor-based experiments

technology

High Aspect Prototype (2001)

- ***Twin projector display***

- A version of this display was shown at the MSR TechFest in 2001.

Large Displays

- ***Why Large Displays?***
  - **Some logical reasons**
    - Would you like your office desk to be the same size as your display? Or vice versa?
    - Today's "large" displays such as a 21" CRT comprise only a few percent of the physical work area in an office.
    - Many UI issues and constraints revolve around not having enough display area to use.

Experimental Hardware

- ***What about user performance?***
  - **Early large display prototypes**
    - **In 1999 and 2000, the HDG built some dual display systems using projectors.**
    - **These systems used two XGA projectors to make a 2048 x 768 pixel display that was about 12 x 34 inches in size. (2.66 to 1 aspect ratio)**
    - **MSR UI researchers (G. Robertson, M. Czerwinski and D. Tan) found out that significant performance improvements were realized over smaller displays.***
      - *Tan, D.S., Robertson, G.G. & Czerwinski, M. (2001). Exploring 3D Navigation: Combining Speed-Coupled Flying with Orbiting. Proceedings of CHI 2001. ACM Press.

DSHARP - The triple display (2002)

- DSHARP stands for Display System using High Aspect Ratio with Projection.
- The prototypes use a Matrox G-200 Quad display card although newer video cards are being evaluated.
- Screen pixel density is about 70 dpi.
- Screen luminance is about 900+ cd/sq. meter or about 6 times brighter than your ordinary desktop display.
- The high luminance reduces eye fatigue and significantly improves color saturation.
- The Hardware products group is providing the capability for additional units if desired – Mike Holm.

DSHARP

- ***Triple display – 4 to 1 aspect ratio***

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DSHARP

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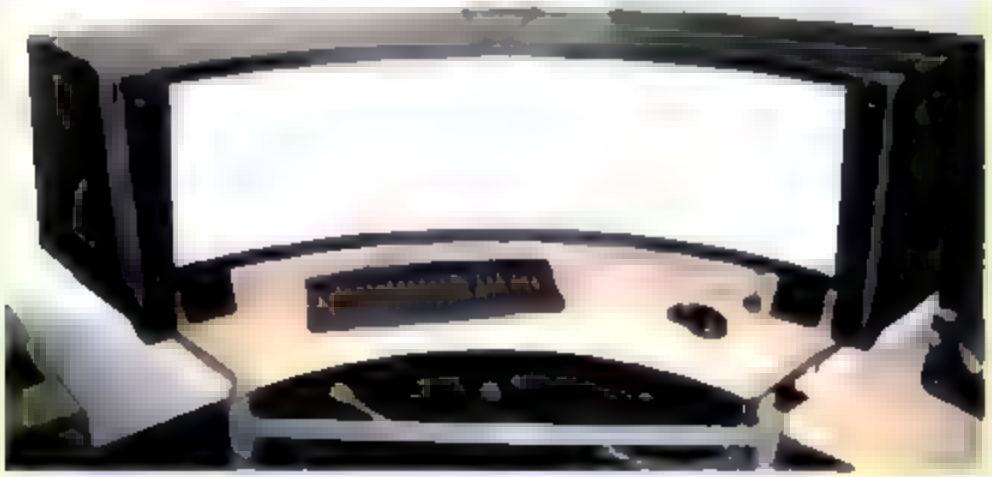
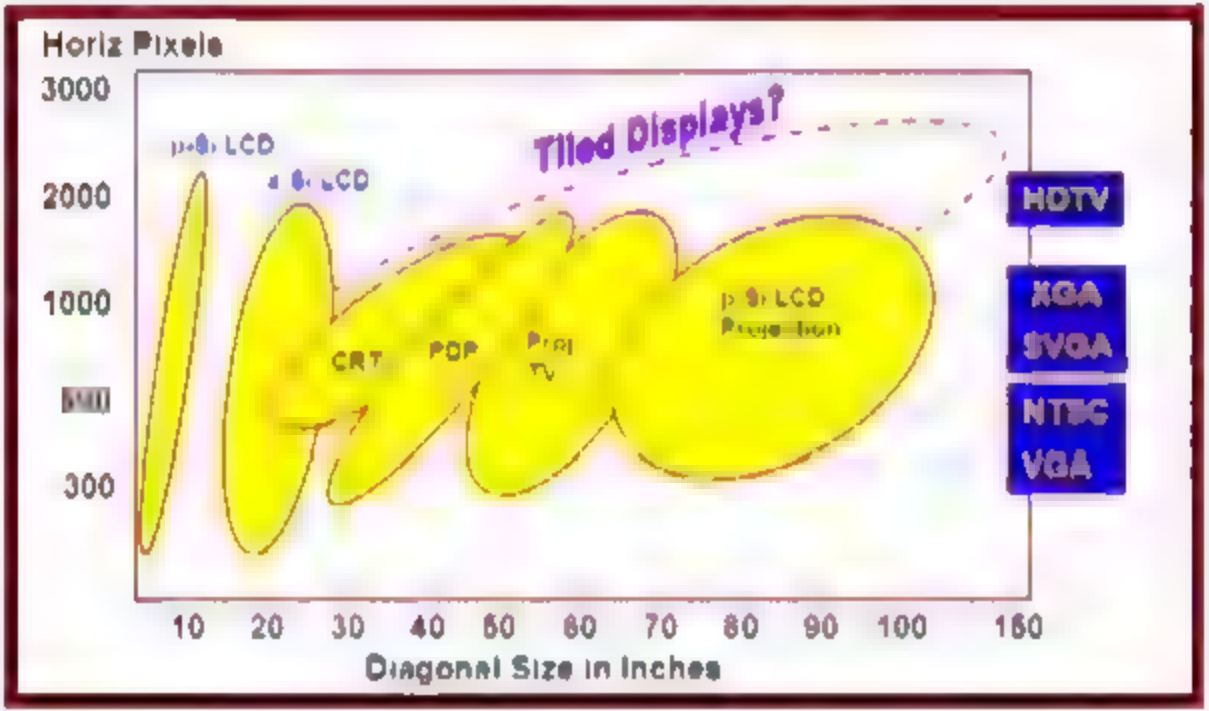


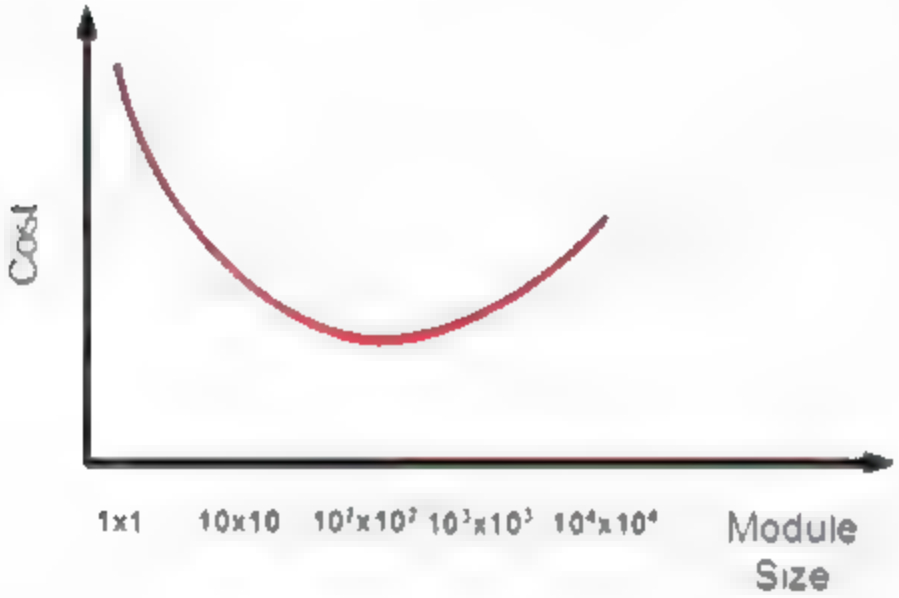
Technology Choice?



What about lower cost and new technology?

- *Practical high volume large display products similar to DSHARP could result from:*
- *(1) Lower cost projection – rather than DLP one might use LCoS (Liquid Crystal on Silicon).*
- *(2) OLED (organic LED) displays made into sheets.*
- *(3) Arrays of mini or micro projectors to provide a "quantized" spatial display element.*
- *(4) Hybrid systems using optics and MEMS.*

IMODS – Integrated MEMS Optical Display



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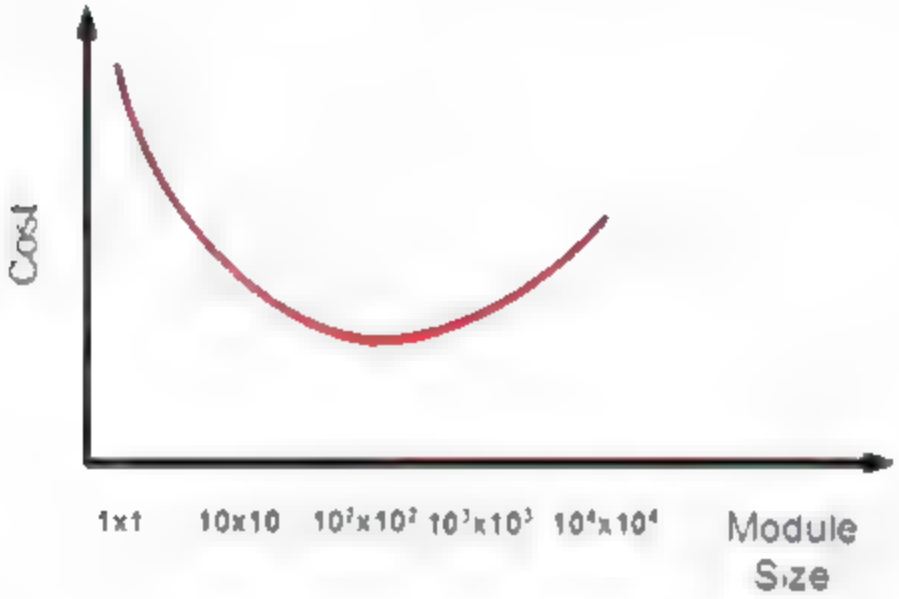

What is the best way to achieve a product?

- *Our concept has been arrays of tiny projectors.*
- *If we want a 5 megapixel display, then 1K $4 projectors with 5 kilopixel resolution would suffice.*
- *How might we make a $4 to $5 projector?*
- *Using 5 ,000 pixel modules could be an important and key solution.* ****
- *If each module covers a square inch then displays would be aspect ratio and shape variant.*
- *The economies of scale apply to the module, not the finished display. This is not unlike ICs.*

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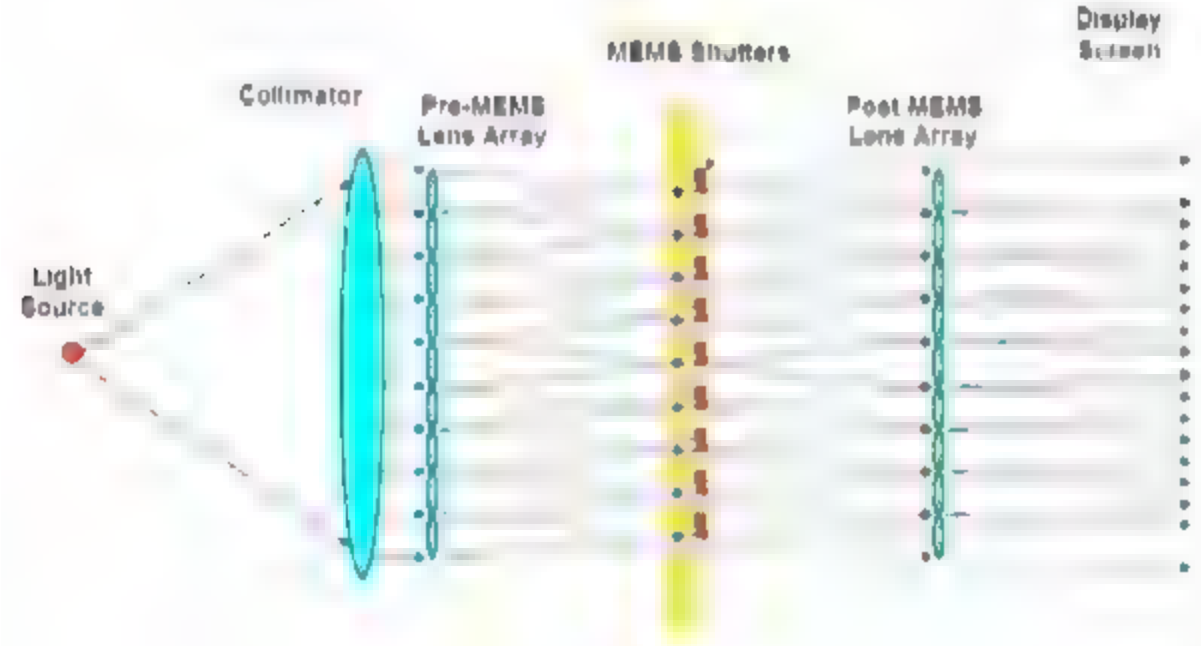

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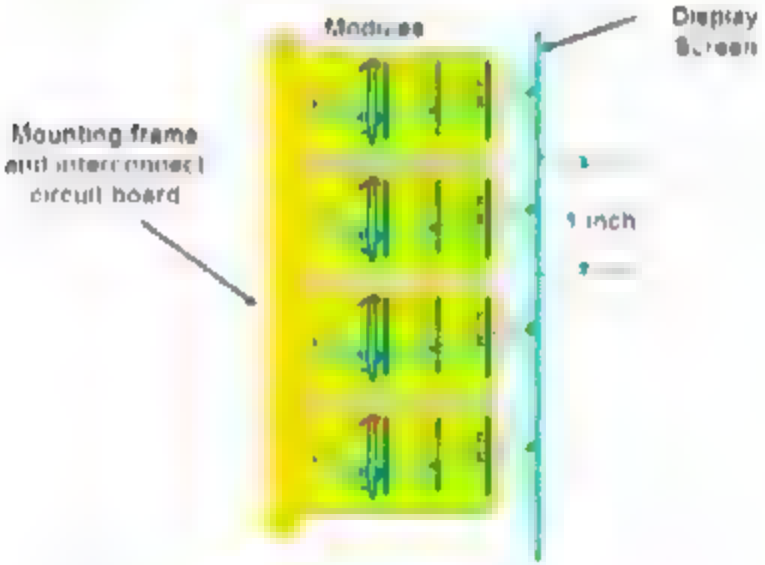
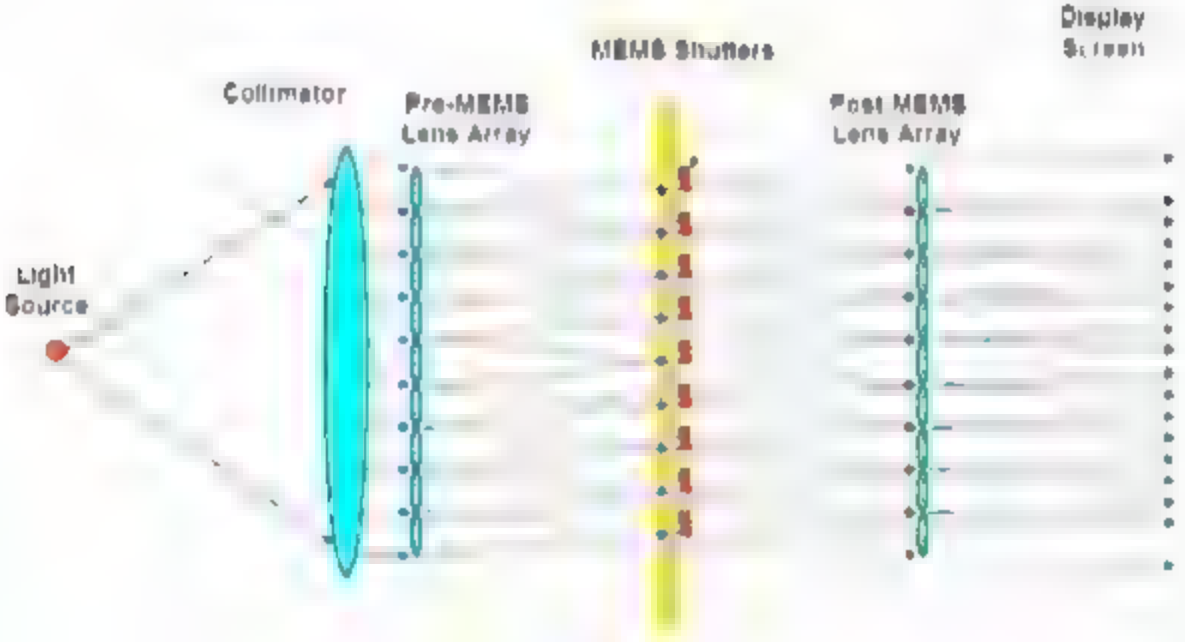


IMODS – Integrated MEMS Optical Display

- Make a functioning IMODS module that at least turns a few pixels on and off and evaluate whether a transmissive mode (IMODS) or reflective mode (RIMODS) is the best option.
- Work with product groups like the hardware products group (Mike Holm and Dawson Yee) to begin technology development/transfer.
- Continue to evaluate alternatives with a large display capability being affordable by most users.
- The goal is to make DSHARP like displays "thin" and very affordable.

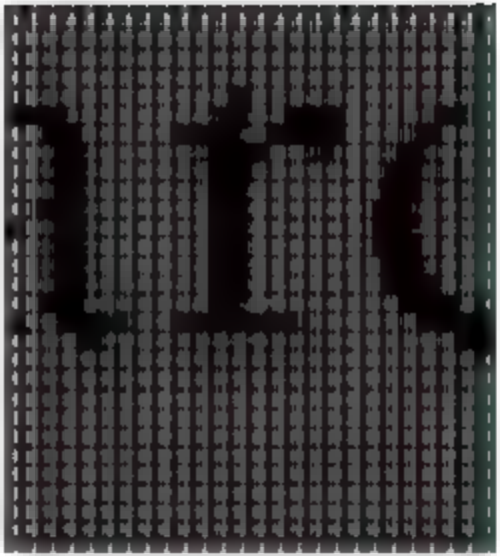
IMODS – Integrated MEMS Optical Display



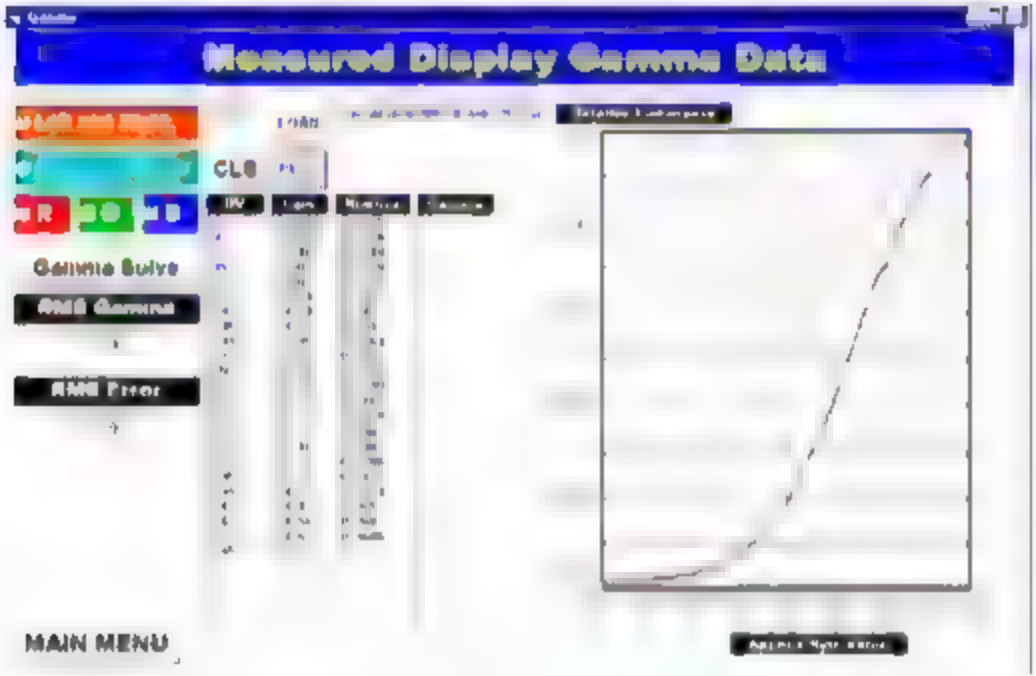
Display characterization

ClearType™

- Resolution enhancement for LCDs
- Optimization according to device characteristics



Measured response



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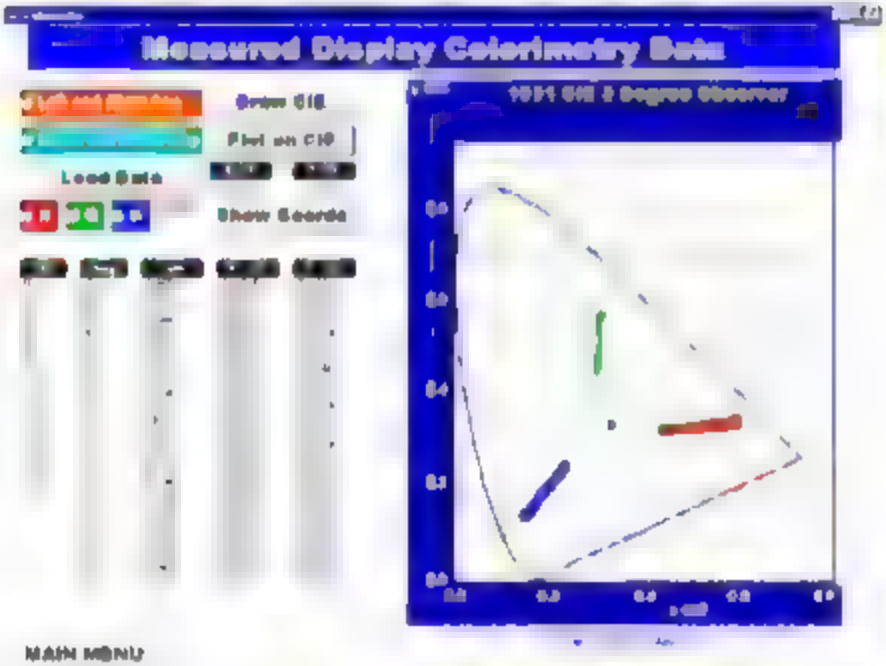

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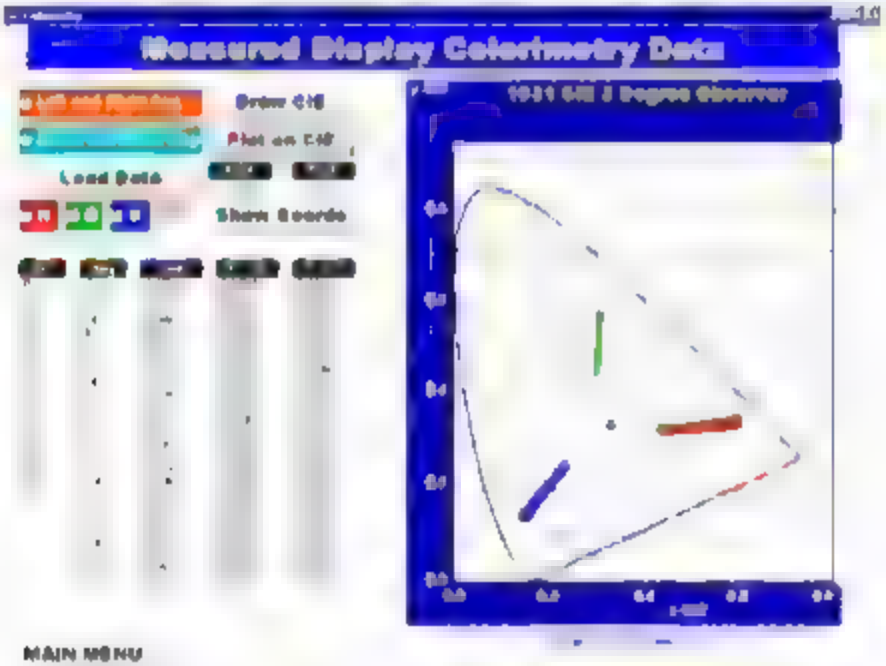
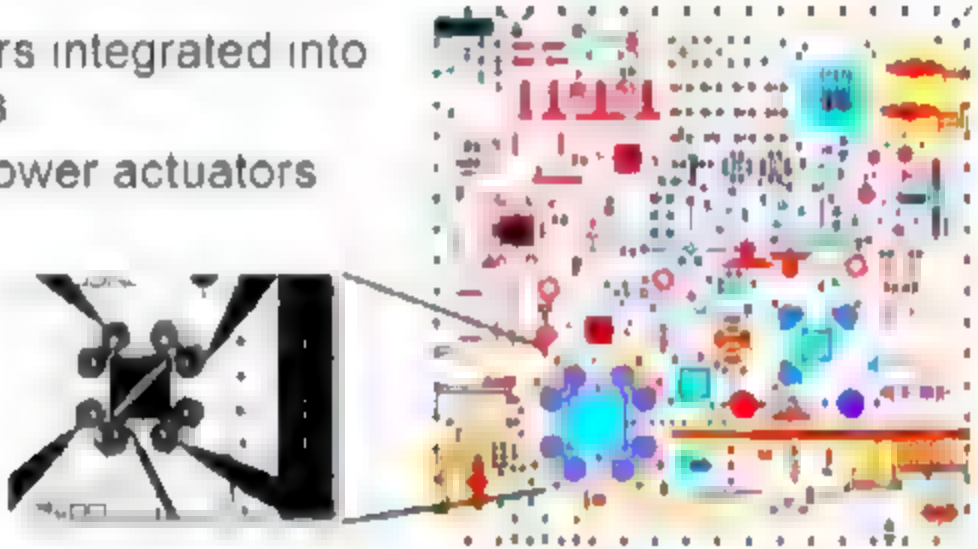


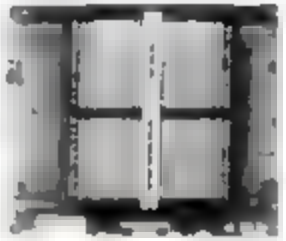
Basic technology: MEMS

- Sensors integrated into circuits
- Low-power actuators

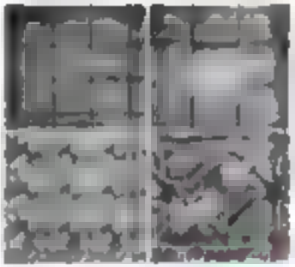


Mike Smelser, MSR

MEMS Applications



- Accelerometer (1, 2 and 3 axes)
  - Airbag deployment
  - Tilt sensor
- Pressure sensing
  - Automotive engine control sensing
- Display
  - Texas Instruments DLP™ chip: 1 million tiny mirrors each toggling at 4K Hz
- Mass storage (future)
  - Many read heads
  - ~10GB cm
  - Small & cheap



MEMS Fabrication

- Bulk micromachining (etching)

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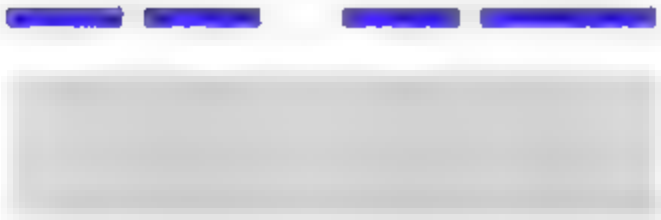

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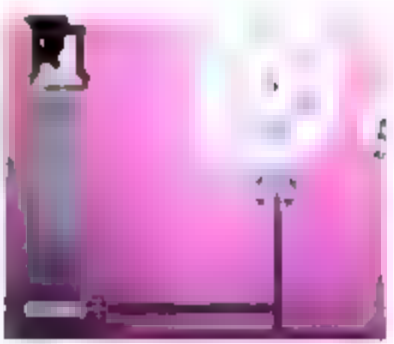

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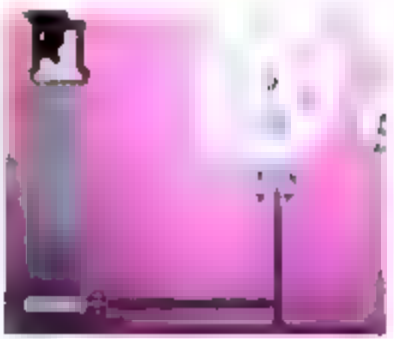

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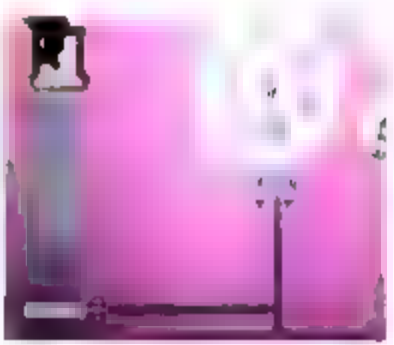

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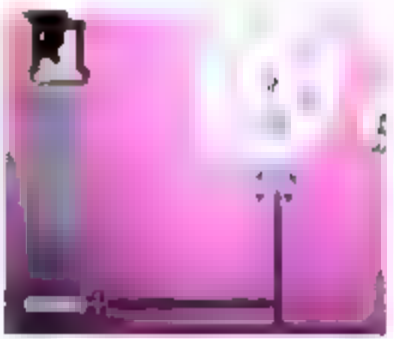

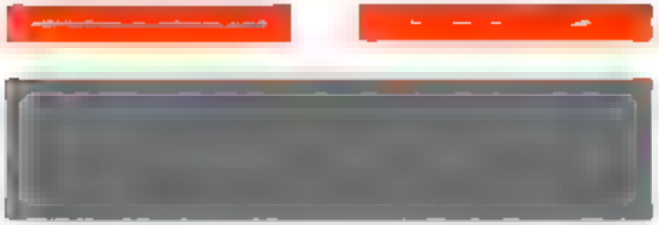

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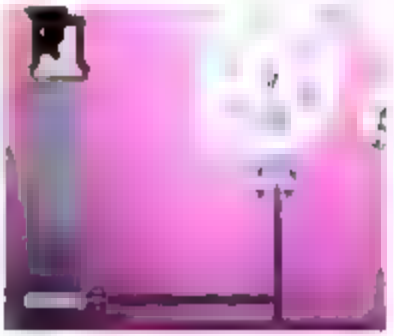
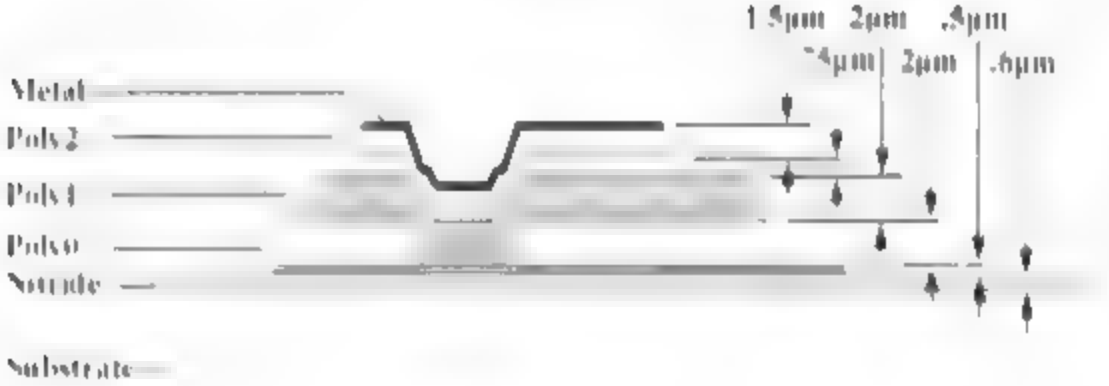


MUMPs (Multi-User MEMS Processes)

Cronos – www.memsrus.com



Early Work – Thermal Chevron Actuator (in-plane movement)

- Ohmic heating causes beams to expand
- 5v @ 120ma excitation
- 2 KHz frequency response (half amplitude)
- >20 µm no-load deflection
- 180x force area over common electrostatic drive
- Device genes s – 2D mirror scanner

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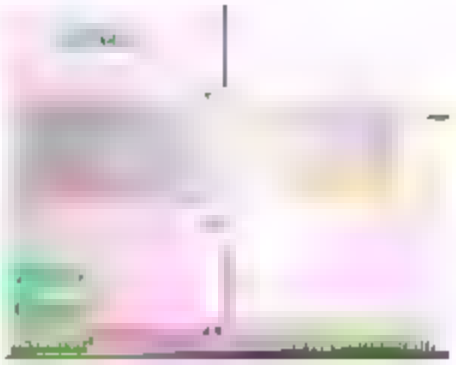

Buckle-Beam Actuator –
out-of-plane torque from electrothermal expansion

- Doubly-clamped cantilever

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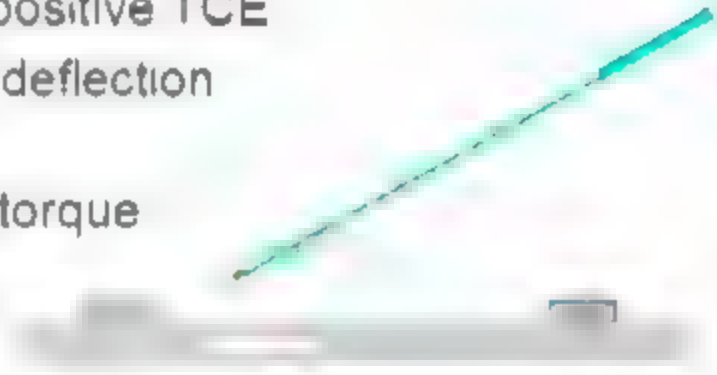
- Add a transverse torque beam, lifting arm and a mirror



Buckle-Beam Operation

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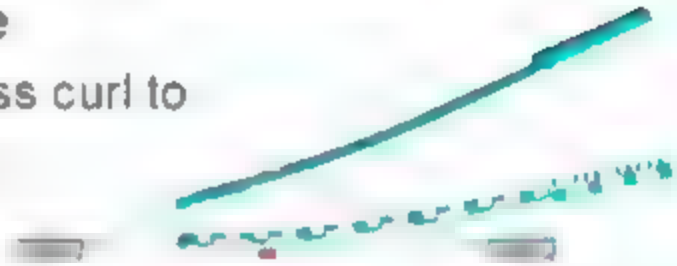

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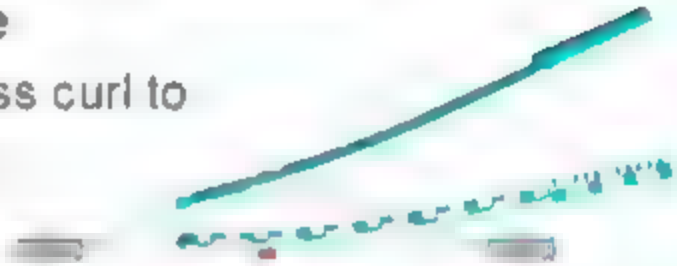

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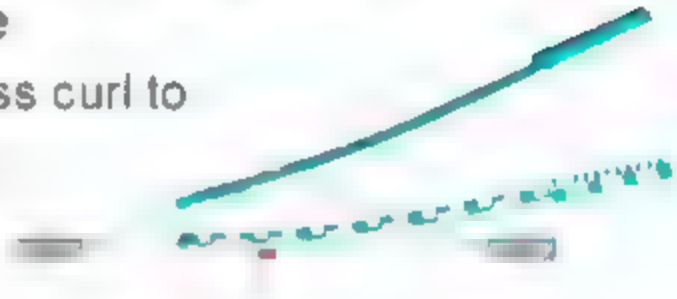

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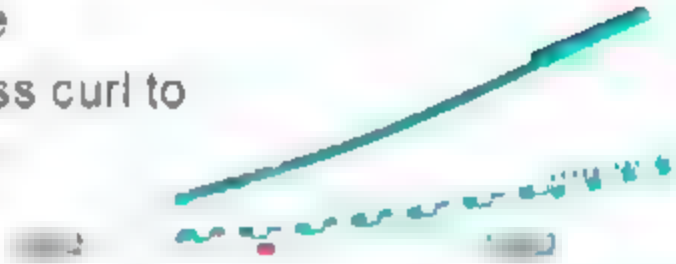
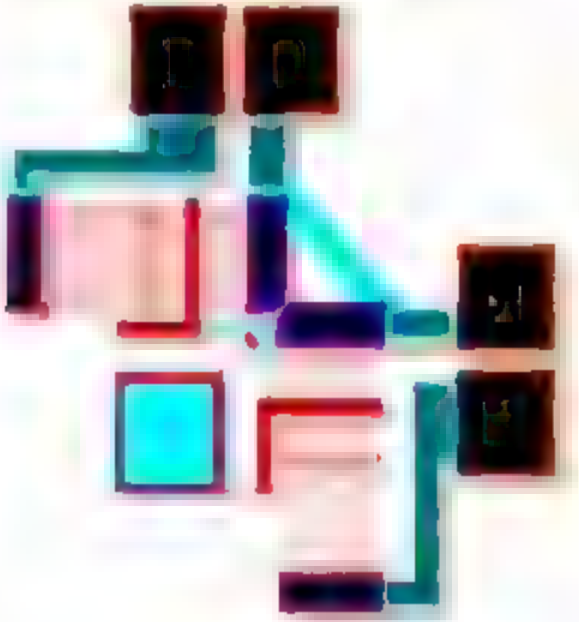


2D Electrothermal Mirror – Vector Display (non-resonant)



2D Vector/Raster Display

- 2D mirror scanner
  - 80 µm mirror
  - orthogonal actuation
  - 8 deg deflection optical
  - 3 KHz frequency response (half-amplitude)

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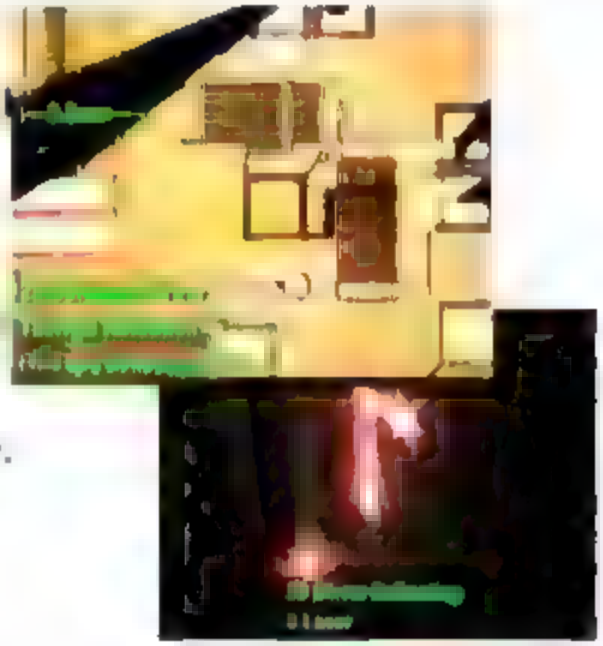
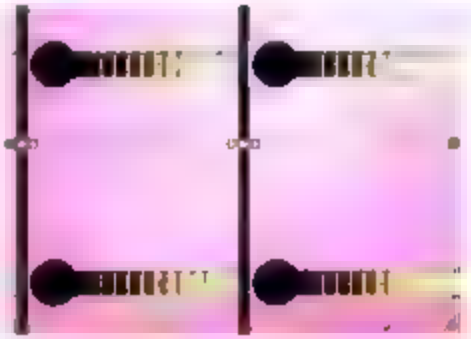


MEMS-based IMODS Displays

small cheap modules for tile-able displays

MEMS Mirror Array (binary)



MEMS-based iMODS Displays

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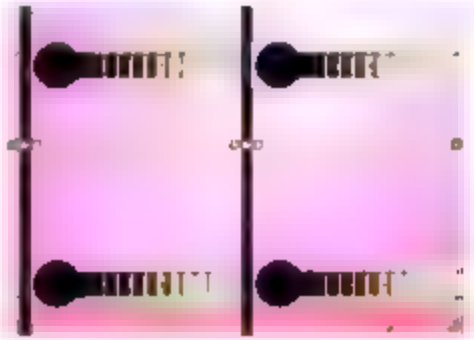


MEMS-based iMODS Displays

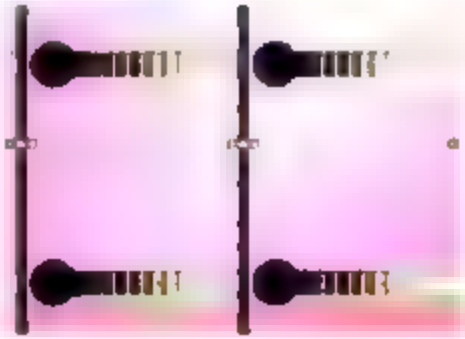
small cheap modules for tile-able displays

MEMS Mirror Array (pixel)

- [illegible]
- [illegible]
- [illegible]
- [illegible]

Other possible MEMS devices

- [illegible]
- [illegible]



Somewhat less exotic

Sensors for UI

- Touch mouse/Touch PDA (CHI 99)
- Video mouse (UIST 99)
- Wrist mouse
- String mouse
- Haptic lens
- Gyro wand
- Linear camera

Physical UI

Sensor-based interaction

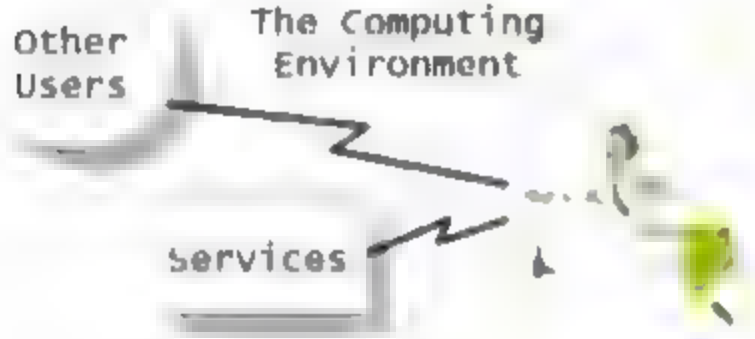
apacitive touch sensor
Mike Sinclair

Ranger sensor
Mike Sinclair

Multi-sensor PAQ – Ken Hinckley, Jeff Pierce, Mike Sinclair, Eric Horvitz

PAQ MacBook – Victor Bahl, Eugene Shih

Invisible Computing: UI for the mobile user



Power supply for the New Century

- If each of us gains 10x the number of appliances will we have the patience to change the batteries?

Power for computation

$$P = C_{eff} V^2 f$$

Grows 13% per year

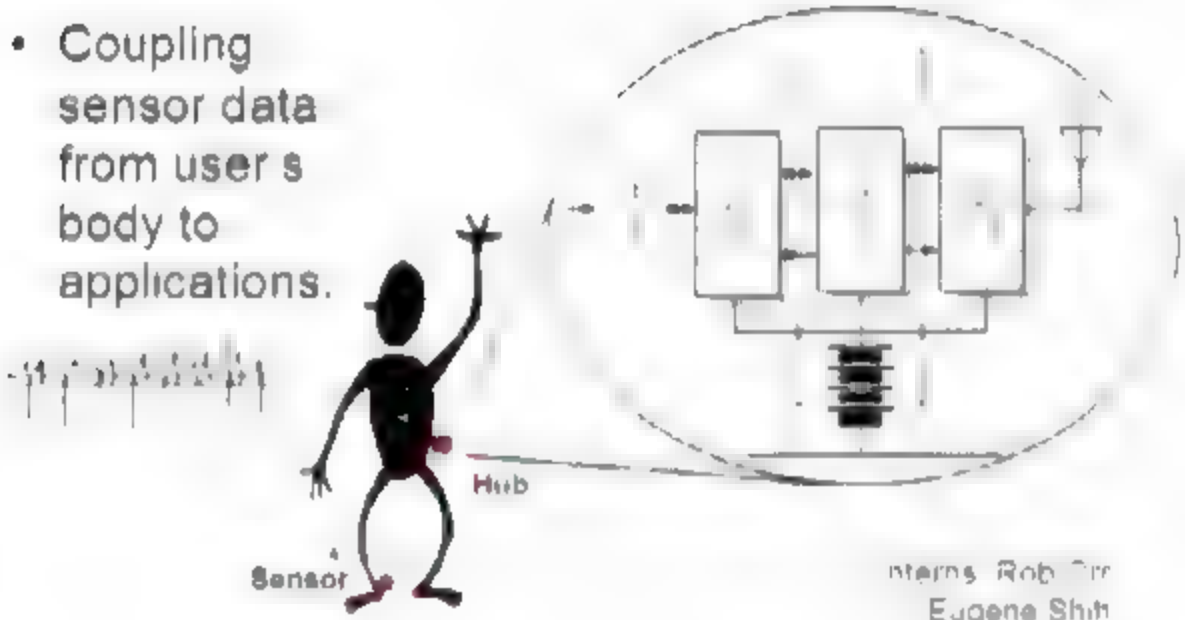
- Lower voltage
- Duty cycle management

Everyday form factors

- Non-intrusive
- Minimal

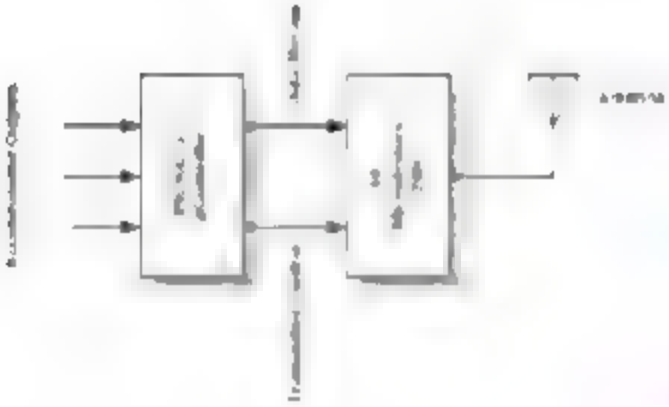
Mobile user

- Coupling sensor data from user s body to applications.



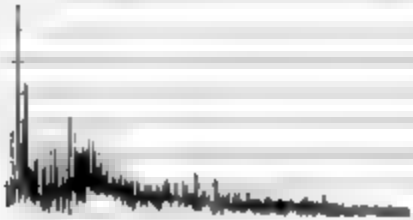
Interns: Rob Ennals
Eugene Shih
Kurt Partridge

BodyLAN prototype

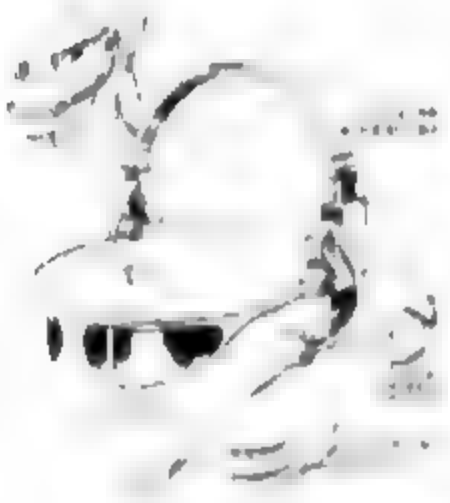


Sensor example (walking)

- Peak detector
  - Low duty cycle
  - Low bandwidth
- Raw signal
  - User identity



Grand-unified user experience



Grand-unified user experience

Group direction

- Projects
  - Applicat on/deployment
  - Not just fundamental technologies
- Personnel
  - Radio communications physical UI
- Products
  - Collaboration with HW group
  - Nudge UI towards more advanced features
- Partners
  - UI LDUX systems vision graphics
  - UW. MIT. ...

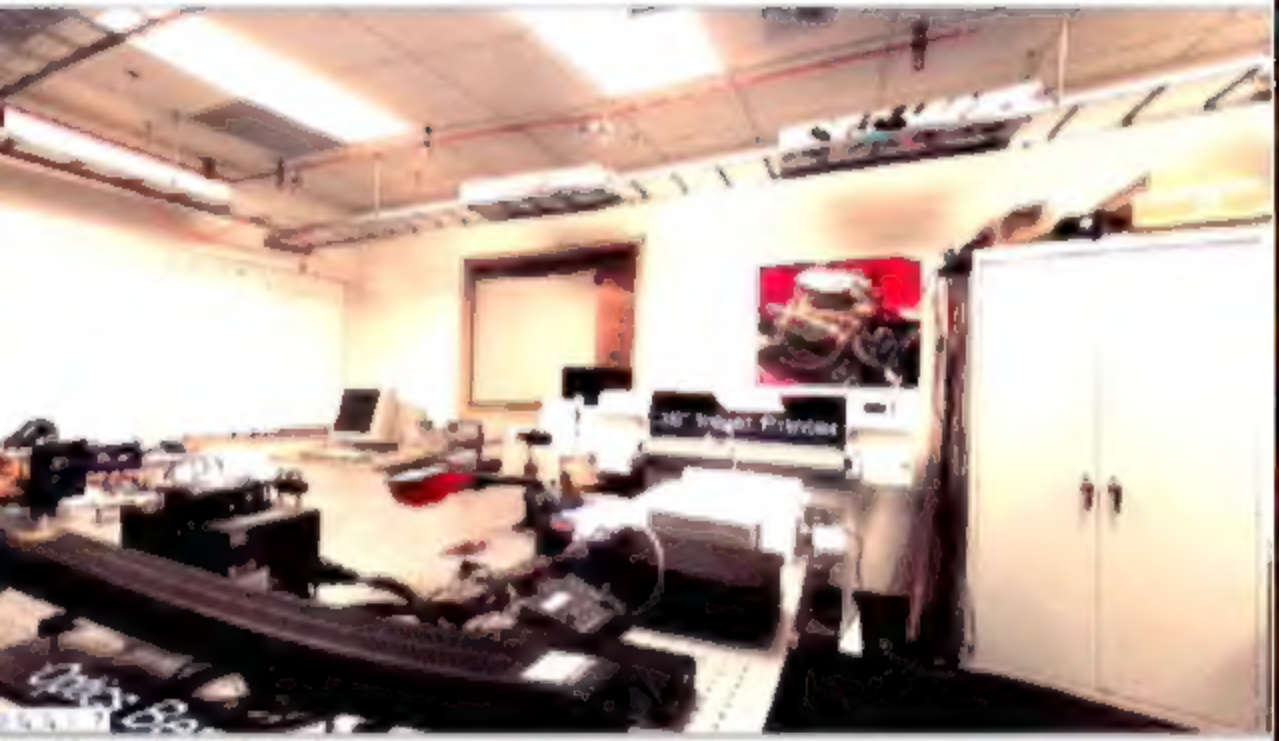
The Lab

Microsoft Research, Hardware Devices Group
Model Shop

Use your mouse left and right buttons to explore!

Research, Hardware Devices Group

EMS and Bodycom Research



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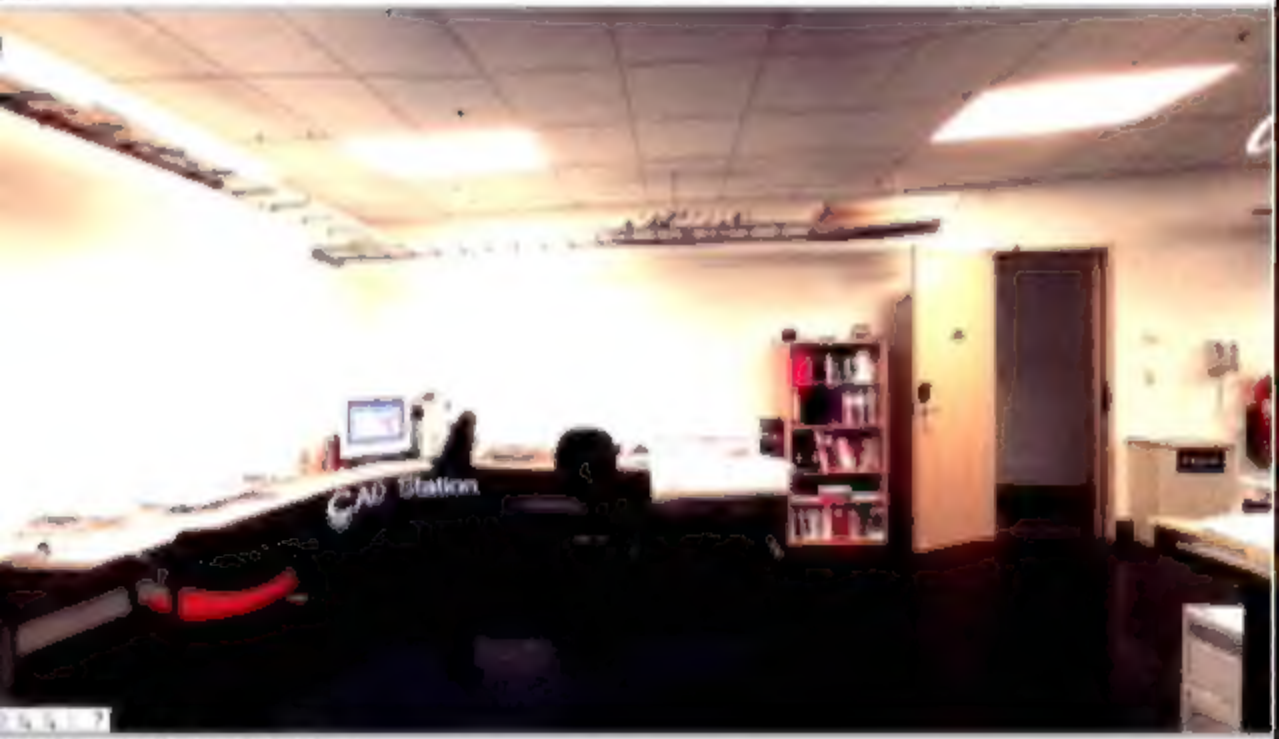
gbox and Touch Mouse Research



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Optics and Touch Mouse Research